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LUMINARY Memo #44

To: Distribution
From: D. Eyles
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Subject: Implementation of "One-phase" Guidance in the AGC

This memo, which is a response to George's LUMINARY Memos 42 and 43, is designed to acquaint those already familiar with the landing programs with the changes made to implement PCR 246, the NASA request for one-phase descent guidance.

So far as the AGC programs are concerned, "one-phase" guidance means (1) switching from braking phase quadratic guidance to approach phase quadratic guidance without the intervention of a linear guidance phase, and (2) giving the vertical component of the desired acceleration vector priority in the allotment of the available thrust acceleration ("radial control"). The AGC program is not "one-phase" in the sense that the braking and approach phase targets ("high-gate" and "low-gate") are necessarily the same, or that the switch from one phase to the other will necessarily show no transients. Additionally, the AGC program is not uniquely one-phase in that it retains the capability of flying two-phase guidance.

Specific changes, and some consequences, follow:-

(1) High-gate and low-gate targets continue to occupy separate erasables.

(2) The switch 2PHASFLG was added. When this bit is clear, the linear guidance portion of the braking phase is skipped, TTF (negative time to go) is not augmented at the beginning of the approach phase,

and radial control is exercised. When this bit is set the opposites are true -- and the result is two-phase guidance.

(3) The time criterion for switching out of the quadratic guidance portion of the braking phase was moved into erasable memory, where its mnemonic is TENDBRAK. This criterion is used regardless of whether the next phase is linear guidance (as in two-phase) or the approach phase itself (one-phase). TENDBRAK is a pad-load. When 2PHASFLG is set it should contain +20 seconds (scaled in centiseconds at 2^{17}); in the one-phase mode its value will be around +200 seconds, but is yet to be determined.

(4) The inhibition of throttle pulse-outs, which formerly took place 10 seconds before the start of linear guidance in each phase, now occurs when and only when TTF exceeds -30 seconds. Thus in the one-phase mode, where during the braking phase TTF never gets that close to zero, pulse-outs will be inhibited only at the end of the approach phase.

(5) Extended verb 68 was added to allow the astronaut to cause immediate switching (within 4 seconds) from P63 to P64. If the braking and approach phases are targetted differently, use of this option may be undesirable. Verb 68 is locked out except during P63.

(6) Since the spacecraft attitude commanded by the guidance equations is mass dependent -- thanks to radial control which must compute the available acceleration as F/M -- the ignition algorithm must know what vehicle mass will be at the start of guidance to eliminate an attitude transient at that time. The mass lost between light-up and the start of guidance may probably be neglected, but any large change in the mass register between the ignition algorithm and the start of guidance by means of uplink or the DAP data load should be avoided.

(7) The radial control logic operates in stable member coordinates. It is assumed that the x-axis of that frame is close to the LM radius vector, and that the y-axis is in the cross-range or out-of-plane direction. Vertical accelerations and out-of-plane accelerations are given priority in the allotment of available thrust. Additionally, it is assumed that while radial control is active (during the high throttle period), the z-component of the desired acceleration is negative.

Finally, familiars of the AGC coding will notice that the "flight sequence tables", which used to be arranged by phase, with an entry for each function, are now arranged by function, with any entry for each phase. The phase indicator WCHPHASE, which used to contain an ADRES, now holds an integer between -1 and 4, depending on the phase. This may interest other programmers as it makes it easier to check which phase is current.

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